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The New Research Department of the Institution.

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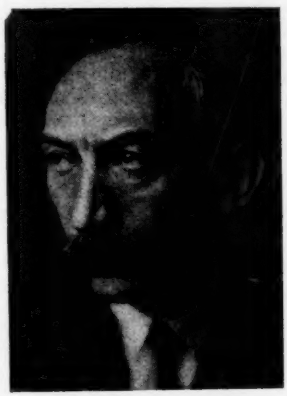
AS announced in our issue of December 29, 1938, the new Research Department of the Institution of Production Engineers was officially brought into operation on January 2, thus inaugurating a project the need of which has long been felt in production engineering circles. The new department has been placed under the direction of Dr. Georg Schlesinger, an expert of world renown in production research.



Dr. Georg Schlesinger.

Dr. Schlesinger has been responsible for the layout of many modern factories in Germany, Russia, and other countries, and among other work assisted the Russian Government in the planning of their production research department where between 1,100 and 1,200 people find constant employment. Although in this country Dr. Schlesinger is perhaps best known for his work in connection with machine tool tests and alignments, there is no aspect of modern production with which he is not familiar, and the new laboratory will be concerned with a wide range of problems bearing on production in its broader aspects.

The necessary accommodation for the Department's laboratory has been provided by the Loughborough College, and it is understood that some of the senior students of the College will be seconded to help Dr. Schlesinger. Although the research activities will thus be centred at Loughborough, some of the important work will be done at various factories in different parts of the country. There are, of course, many aspects of production which cannot be studied adequately in a laboratory. however well equipped. Problems relating to the handling of work, the economics of fine finish, industrial safety, and planning and processing, are for example, matters which require the co-operation of factory executives. In addition to the co-operation of factories, it is hoped that assistance in specific research work will be obtained from various colleges and universities throughout the country, where suitable equipment is available, and also that co-operation with other engineering institutions will be possible.

Among the subjects suggested for research may be mentioned the materials and tools used in cold forming ; the standardisation of surface finish and its measurement ; the effect of vibration on productive efficiency ; machine guards and the possibility of their standardisation ; modern cutting alloys, and cutting fluids. It also seems likely that the standardisation of machine tool tests and alignments is a matter to which attention will be given at an early date, while the design of machine tools from the user's point of view is a subject which may also be considered. In connection with the design of machine tools, useful research may be conducted to compare ground slides with scraped slides, and hardened steel ways with ways which have been machined from the chilled casting.

Summarised, the aims of the new research laboratory will be to assist the engineering designer to give a better and cheaper product. An example will perhaps serve to indicate the importance to the designer of production research.

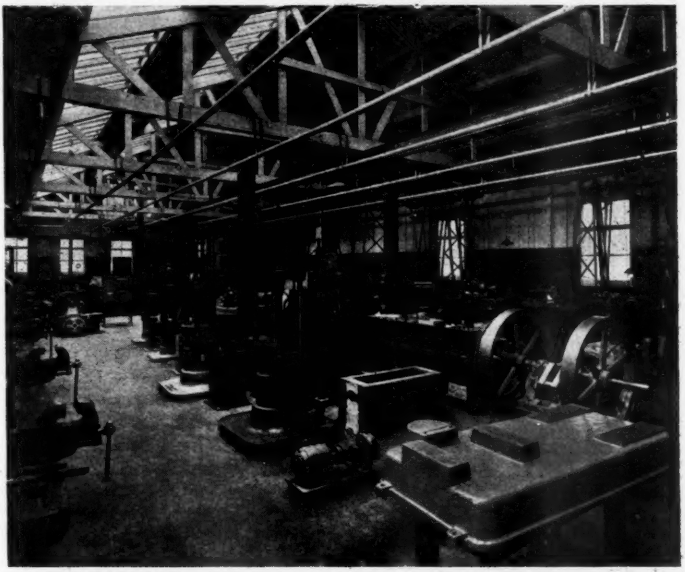
The designs for a highly successful type of radial sleeve valve aero-engine were completed some time before production could be commenced, as the manufacture of some of the important components entailed intensive investigation from the standpoint of production. Not until special production equipment and methods had been perfected, was it possible to proceed with manufacture on a production basis.

A scheme of the magnitude of that envisaged by the Institution of Production Engineers will, of course, require funds. The generous gift of £25,000 by Lord Nuffield, President of the Institution, provides a useful beginning, but it is understood that an income of something like £10,000 per annum will be needed before the Department of Scientific and Industrial Research would agree to give a large annual grant. The Institution has decided to hand over to its research

Department 80% of the annual subscriptions it receives from its affiliated firms. In addition, it will have to look to the engineering industries of this country for liberal financial backing.

Production Engineering Research.

It is unnecessary here to stress the importance of the enormous amount of research and experimental work which has already been carried out in this and other countries in connection with the various aspects of engineering and metallurgy. Such work ultimately controls the rate of progress, and since the pace of development is not only being maintained, but is tending to quicken, so the demands upon the research worker are becoming more insistent. The aero-



A View in the Research Laboratory of the Institution of Production Engineers at Loughborough College. New Equipment is to be installed to meet requirements.

engine designer, let us say, utilising the results of the latest investigations in his particular field, plans a unit of an advanced type. The design may be highly satisfactory in theory, but the working conditions to which certain components would be subjected might be too severe for the available materials. It is then the turn of the metallurgist to develop improved alloys which will fulfil the specified requirements. Finally, it falls to the lot of the production engineer to translate the ideas of the designer into a

concrete form and with a minimum expenditure of time and money. It may well happen that some of the parts called for are of such a form or required to be made to such close limits of accuracy that their economic production with existing plant and methods is impossible. The production engineer must then devote his attention to devising new or adapting old methods, or must refer the problem to the machine tool builder. When a solution has been found, it may well represent a definite step forward in the science of production, but a considerable period may elapse before it is recognised as such.

Quite apart from the work which is done in devising practical means of overcoming particular difficulties, moreover, the makers of machine tools and small tools are constantly engaged in improving their products and broadening the field of application. There is thus increasing competition not only between machines of different makes, but between entirely different processes. Under these circumstances, it is not surprising if the production engineer is sometimes a little bewildered, and finds that the march of progress is so rapid that there is no opportunity of consolidating the ground already won. When, as is frequently the case, a number of alternative methods of arriving at a given result present themselves, he will usually seek in vain for reliable comparative data, which would enable him to determine with certainty the best and most economical process to employ. The problems of the production engineer are by no meas confined to actual machining, but are concerned with every stage in manufacture from the raw material to the finished product, and it is necessary, therefore, also to be alive to the possibility of an additional expense in one department effecting an overall economy.

It is with a view to shedding additional light on some of the aspects of engineering manufacture that the new Research Laboratory of the Institution of Production Engineers has been established at Loughborough College. The difficulties of the work which is to be undertaken and of the presentation of the results in a practical form are very great, but the Institution, as one might expect with that enterprising and progressive body, has not been deterred thereby. Certainly a good beginning has been made in securing the services of Dr. Georg Schlesinger.

If the progress made is to be commensurate with the magnitude of the task, the work obviously cannot be confined to Loughborough, and it is to be hoped that it will be possible to enlist the aid of other educational institutions, and, what is more important, of large engineering shops. Substantial financial resources will, of course, be essential, and in view of the potential value of the researches to industry, generous support should be forthcoming to permit of speedy qualification for assistance from the Department of Scientific and Industrial Research.

Inaugural Meeting of the Nottingham Section.

THE Inaugural Meeting of the Nottingham Section of the Institution was held at the Black Boy Hotel, Nottingham, on December 8, 1938. Lord Sempill, Deputy-President of the Institution, presided during the earlier part of the proceedings, later handing over the chair to Mr. H. J. Gibbons, first President of the new Section. During the second part of the proceedings. Mr. R. H. Youngash, member of Council, delivered a lecture illustrated by lantern slides, on "Tool Room Practice," and this was followed by an interesting discussion. Among the members of Council present, in addtion to Lord Semphill, were Mr. James G. Young, Chairman of Council, Mr. J. D. Scaife, Past-President, Mr. J. H. Bingham, Immediate Past-Chairman of Council, Mr. N. V. Kipping, President of the London Section, Mr. W. C. Puckey, and Mr. R. H. Youngash. There was a large attendance, all the leading engineering firms in Nottingham and district being represented, while Derby and Lincoln were also represented. Sir Ernest Jardine and Professor Bullied, President of the Nottingham Division of the Institution of Mechanical Engineers, occupied seats on the platform.

THE RIGHT HON. LORD SEMPILL, M.I.P.E., (*Deputy-President af the Institution*) : Firstly, I would like to tell you how sorry our President, Lord Nuffield, is that he is not able to be here. As you know, he has much to do and it is not always possible for him to give the time that he would like to the affairs of the Institution. He takes a very keen interest in it, however, and has given orders to his staff that all technical and other important papers relating to the affairs of the Institution are to be put before him without delay. Here is a message from our President :—

> My active thoughts are ever with those whose working hours are given to the all-important question of Production Engineering. I am proud to be your President, and send my good wishes to the Nottingham Branch being inaugurated this evening, and take this opportunity of paying tribute to the indefatigable energies of Mr. Bingham, the immediate Past-Chairman, and Mr. Young, Chairman, who have both done so much to bring about the formation of this new Branch. That it will assist in carrying forward work of National good, I have no doubt.
>
> (Signed) NUFFIELD.

While our Institution, which was founded in 1921, has not yet reached its twenty-first birthday, this gathering has to do with the formation of our 21st local section, which means that branches have now been established in most of the important industrial centres in England and Scotland. A start has also been made overseas, with the establishment of a strong section in Sydney, Australia.

Local Sections in the organisation of the Institution of Production Engineers occupy a different position from those of the older institutions which may be regarded as London bodies with provincial branches. In our case the sections *are* the Insitution. There is a considerable difference. The new Nottingham Section will, for instance, be equal in status with all the other sections, including London, and will exercise the same rights and powers in relation to the government of the organisation. In that way our Insitution is truly national and thoroughly representative. The President and Committee of the new Section will have power to settle their own programme and control their own affairs, but they will be linked with the other sections and with the London headquarters by representatives on the Central Council. Thus a wide measure of decentralisation, combined with unified control and direction of national policy, is secured. Only every other meeting of the Council is held in London.

The Council plays a vital part in the direction of the Institution's affairs. It works largely through representative Committees. At the next Council Meeting, which is taking place the day after tomorrow, the annual re-appointment of the Standing and other Committees will be dealt with. These include a Finance Committee, Development Committee, Membership Committee, Examinations Committee, Joint Examination Board, Standards Committee, Research Committee, India Advisory Committee, and so on. Also there is our Advisory Committee to the City and Guilds of London Institute on Machinists', Turners' and Fitters' Work. In addition, representatives will have to be appointed to a large number of outside organisations, including the British Standards Institution, the British Management Council, Headmasters' Employment Committee, the Joint Committee on Materials and their Testing, and so forth. Our Insitution is represented on at least 20 sub-committees of the British Standards Institution, as well as on its Mechanical Industries Committee. In all this, there is an immense field of useful activity.

While our membership at present is just under 2,000 it is growing at a most satisfactory rate. For instance, at the Council Meeting on Saturday there are 116 candidates for election to the various grades. There is now no doubt that in due course this Institution will be among the largest and most important of the engineering organisations of the country. Most of the other institutions are

mainly preoccupied with questions of design and invention. They do not cater directly for the workship engineer, who, so far as the scientific side of his work is concerned, was a "forgotten man" until the Institution of Production Engineers was formed. Now, however, that the main emphasis is coming to be placed on production—and even in the case of design, on "design for production"—the Production Engineer is coming into his own.

Whatever the nature of the engineering product—be it a motor-car, a typewriter, an electrical generator, a railway engine, or anything else—the problems involved in its manufacture are the prime concern of the production engineer. It is he who has to settle the planning of its production, the machines on which it is to be made, the jigs and fixtures reouired, the kind of labour to be employed, and the countless other details on which the speed, economy and efficiency of manufacture depend. He must be an organiser as well as an engineer, a good psychologist and a practitioner of scientific management.

Members of nearly all the other engineering institutions are to be found in our ranks—civil engineers, mechanical engineers, electrical, structural, marine, automobile, gas engineers, heating and ventilating engineers, and so on. That is likely to be increasingly the case in the future wherever the members of those other institutions have to do with the manufacture as well as the design of particular products.

On the other hand, the chief production engineers and the production managers of some of the largest works in the country do not belong to any engineering institution other than ours. We stress the practical side of engineering, while most other institutions stress the theoretical or academic side. It is not possible, in practice, for any one institution in this country to cover both sides adequately, any more than it has been found possible, on the design side, to have only one institution here to cover civil, mechanical, electrical, marine, aeronautical automobile or other sections of engineering.

It is not too much to say that with the position and the prestige that the Institution has already acquired, it is now the recognised body in this country speaking for production engineers. Under its Memorandum of Association, the Institution has but the one sole object—"To promote the science and practice of production engineering," and it is bending all its energies to that one object. Formerly, production engineering was largely an art : to-day it is evolving from that into a science, and it is our task as production engineers to promote that transformation from an art to a science by every means possible.

May I make a few remarks on the main activities of the Institution? From 150 to 200 lectures are held every session. The aggregate attendance now numbers close to, or over, 10,000. A

selection of these lectures is, with full reports of the discussions on them, published in the monthly Journal of the Institution, and form an outstanding contribution to production engineering science and the science of production management.

In the case, now, of a rapidly developing science such as ours, the question of technical education is one of the utmost importance. As I said before, the Institution has its Examinations Committee, and also its Joint Examination Board, and for the past eight years it has had the help and advice on that Board of the principals of some of our largest and best technical colleges in the Kingdom—Dr. Schofield, the Principal of Loughborough College, Dr. Fisher of Wolverhampton, and Dr. Anderson of Birmingham. On the advice of the Board and with the support of those principals, the Council of the Institution decided to apply for a National Certificate in Production Engineering last December, and at the request of the Council, Lord Nuffield and I paid a visit to the Board of Education and saw Lord Stanhope, who was then in charge of the Board. Since then there have been more discussions, and the matter is still under consideration. It is not easy to settle a question of that kind, as it involves many important questions of policy and is interlinked with other branches of engineering, but we all have a firm belief in the rightness of our demand, and a sure conviction that before very long there will be a National Certificate in Production Engineering.

The Board of Education has also given its approval to the proposal that the laboratory of our new research department should be established at Loughborough College. At Loughborough only a few days ago, when the annual prize-giving Speech Day was held, the premises that are to be set aside by the College for this purpose were inspected, and they are very adequate in every sense for this exceedingly valuable work. Dr. Schlesinger, who is undoubtedly a very eminent man, has been selected as our Research Director. We are convinced that he is the most suitable man to start our Research scheme, and therefore he has been so appointed and will take up his duties on January 1. I have no doubt that the work will be exceedingly valuable.

There is, of course, as Mr. Jenkins, President of our Luton Section, has well observed, a great gulf between the production methods now in use and those that prevailed prior to the design and manufacture of the motor-car, and its acceptance by the public as a satisfactory means of transport. Its quick acceptance and adoption brought in its train manifold troubles and problems not previously experienced in engineering production. The necessity for fine accuracy and interchangeability of parts soon became apparent, and existing methods of production were proved to be thoroughly inefficient and obsolete. Up till this period the manufacture of any mechanism was largely a work of art depending for its effective

functioning upon the art and applied skill of the mechanics engaged upon its manufacture. Relative accuracy of the mating parts was in most cases quite sufficient. Interchangeability, in the modern sense of the word, was, to all intents and purposes, non-existent. Exception could be made in the case of certain specialised cases such as scientific instruments. These were of an extremely expensive nature where interchangeability and fine accuracy were desirable, but as demand was comparatively low, the difficulty was not of a serious nature. The development, however, of the motor-car, led to ever-increasing demands for greater accuracy of component parts, more durable materials and increased power from smaller and lighter power units.

At a later stage the introduction of the aeroplane engine served to accentuate these demands. The outlook of the metallurgist, the steelmaker and the machine tool manufacturer was revolutionised by the requirements of this new phase of engineering. It should be realised that each one of these branches of the industry has in existence a background of scientific research, going back for over a period of at least twenty years. The fundamental principles underlying their activities were clearly understood, and progress was, therefore, consistent and rapid.

On the other hand, it soon became apparent that the production side of all branches of this industry was sadly lacking in a scientific approach to its problems. The necessity for scientific layout of plant, specialised tools and machinery and scientifically planned layout of operation sequences became a problem of almost overwhelming importance. In other words, Production Engineering was becoming a science rather than an art. New methods of production, starting from design and finishing with the completely manufactured article, were gradually evolved.

Manufacturing, inspection, and measurement for accuracy were placed on a controlled scientific basis. Manpower was organised, output per man was vastly increased, and at the same time, the condition of the workers within the industry became more prosperous. The repercussions of the new methods of production engineering were felt in every phase of productive industry, going far outside engineering.

The machine tool industry was entirely revolutionised, and machines were designed not merely as tool carriers, but as scientifically designed users of tools. In many cases, even up to the present time, where the desired accuracy could not be built into a machine tool, jigs and fixtures giving a much closer control of accuracy, independent of the art and skill of the operator, were devised. A new type of engineer has been developed whose main functions are the scientific investigation of production problems, the scientific application

of tools to materials, and the scientific utilisation of all types of labour from the unskilled up to the highest skilled man available.

Considerations such as I have dwelt on led successive presidents of ours such as Lord Austin, Lord Nuffield, Sir Alfred Herbert, Sir Walter Kent, Mr. Thorneycroft, and others, to realise that in the evolution of industrial processes our Institution could play a role of great importance to them and to their activities. They have, consequently, done their utmost to expand its influence and authority.

It is the production engineers behind such eminent manufacturers who have made their success possible by bringing their products within the reach of an ever-widening market. Lord Austin, for instance, has often quoted figures giving the cost of his first few cars, and the wages paid, and then gone on to quote astonishing reductions in selling prices combined with equally astonishing increase in output and in the rise in the proportionate wages of his employees. A similar record could be quoted by a vast number of other manufacturers. It is that section of the engineering profession which has come to be known as production engineers that has been largely instrumental in bringing about the industrial transformation of to-day. The study of manufacturing processes is the work of the production engineer. It is his business to take the completed design of the mechanical engineer, the aeronautical engineer, the automobile engineer, or other design engineer, and produce the finished article with a minumum expenditure of human labour.

The specialised work of the production engineer is work that cannot be efficiently done by engineers in any other branch of the profession already fully engaged in other activities. For the same reason, the work of the Institution of Production Engineers is work that cannot be efficiently done by any other engineering institutions already fully engaged in other activities. The evolution of the specialised production engineer in our time has called this Institution into being in order to promote the science and practice of that specialised branch of engineering with which he deals. The Great War gave an enormous impetus to the evolution. The urge to form our Institution sprang out of the chaos the country was in, from a production point of view, at the beginning of the war. The problems of production engineering could no longer be safely left in the hands of other engineering institutions which, because of their preoccupation with design and invention, were bound to relegate production to a secondary place. To-day a very large proportion of the country's re-armament work is directly in the hands of members of this Institution, and Ministers of the Crown, such as the Secretary of State for Air and the Minister for the Co-ordination of Defence have paid tribute on more than one occasion to the work of national importance which the Institution is doing.

A large number of messages wishing the new Nottingham Section success was then read, including a letter from Lord Austin, Past-President, and messages from the Presidents and Committees of other local sections.

Mr. J. H. BINGHAM (*Immediate Past-Chairman of Council*): I do not think I can enlarge to any great extent on what has been said already by Lord Sempill about our Institution, but knowing that people sometimes come to a meeting of this kind looking as though they wondered what it is all about and feeling that there may be still some curiosity unsatisfied, I, having had some experience, will try to tell you.

This Institution is the one which recognises, and rightly so, that production engineering has its own peculiar problems, to each of which there is a scientific approach, and that these problems require individual and concentrated treatment. Production engineering employs the resources of the more exact sciences to solve the problems of construction and of industrial production in the most economical manner. The thousand and one things that the production engineer makes are less significant, from our point of view, than the way he makes them.

The production engineer himself has a sharply defined though not necessarily localised area of work by which he can readily be distinguished. He begins by making a scientific analysis of the more promising methods of solving his problems, after which he counts the costs and estimates the returns of the promising solutions in order to decide the method which promises the best ratio of utility to cost. Having done this he reduces the solution to a systematic, detailed programme of procedure which he executes by mobilising men, materials and machinery in a highly co-ordinated sequence of action.

The Institution is alive to the fact that the production engineer's responsibilities are increasing with the growth and expansion of industries, and it is its desire and endeavour to keep him well equipped for his job. On the question of education and training I would like to make a few comments without wishing to be too critical.

Whatever may be one's views on the most expedient scheme of organisation and curriculum it can scarcely be denied that the technology of tools and of production has received less than its due in most engineering colleges. The advances in tools, processes and materials have come from the industries with almost no help from college laboratories. The shop courses in comparatively few of our engineering colleges have as yet risen to the plane of scientific laboratory instruction. More often they have remained as fairly routine and sterile hang-overs from a time when engineering colleges felt an urge to be practical.

We of the Institution claim that we have given the profession of production engineering a more salient character from which we can project its educational aims and methods to appropriate educational standards. The Institution feels that in the pursuit of its claim for a National Certificate in Production Engineering it is defining a channel along which students for the profession can be directed towards their ultimate objective.

We have been prompted to move towards the provision of this Certificate by the growing demand among manufacturers for qualifications for those responsible for factory production analagous to the ones recognised in the three National Certificates already approved by the Board of Education. With the increasing adoption of mass production in more highly developed forms, they appreciate the urgent need for a supply of specially trained and qualified men capable of managing complicated mass-production systems.

We are being encouraged also in our efforts in this direction by the knowledge that a number of technical and engineering colleges have provided courses in production engineering, and that the principals of those colleges are anxious for their students to pass examinations qualifying for a National Certificate recognised by the Board of Education.

And now I would like to refer to our Research Scheme already referred to by Lord Sempill. Viewing industry as a whole, the technical complexities and the risks they involve appear to be growing in importance with the use of automatic equipment, highly standardised processes and closely interlocked sequences of operation and interchangeability. Furthermore, competition is developing chiefly between products rather than individual firms, and industrial research has been widely seized upon both as a competitive weapon and means of defence.

Critical studies in the physical and economical limitations of tools and researches in the basic phenomena of shop processes have been rare, almost non-existent in this country, but actively pursued in the technical universities of Central Europe. Research has been neglected here ; in some other countries the teaching of production technology is a direct outgrowth of research.

In launching its Research Scheme the Institution is going forward with an earnest desire to provide a real service to industry and to satisfy a long-felt want. The Institution is very fortunate in having had placed at its disposal the facilities at Loughborough College. It is particularly fortunate, thanks to the munificence of Lord Nuffield, in having been able to obtain for the direction of its Research Department, the services of Dr. Schlesinger, the outstanding personality in the field of production technology in Central Europe.

At the same time it is realised that the ultimate success of the research scheme depends on the manner of its presentation to and acceptance by Industry, on whose support it must rely for the continuous conduct of it, but as the field for research is a vast one, embracing, as it does, all sections of manufacturing industry and no one in particular, the field for appeal is equally vast.

It is with an unshaken confidence in our ability to impress upon Industry that we have a valuable service to offer it which will ensure its wholehearted co-operation and financial support that we are pressing forward the plans and programme for our research organisation.

We of the Institution learn what the Institution stands for as we live with it. We gain our idea of what it means from the examples of what it does. What it has done already has been of supreme importance to the progress of the science of production engineering and immeasurable advantages have already accrued to the industrial community of our country from the work which the Institution has done.

Our Institution is organised for progress. We are proud of the progress which has been made. There has been growth in numbers, growth in character and in the effective influence upon the membership and upon the industrial community which it serves. All this has been achieved by a constant deepening consciousness in the membership and by that I mean a serious acceptance of purpose. We feel that we have no cause for shame in our record as far as it has been written. In its further inscription we are definitely counting on the assistance of this new section. We congratulate ourselves now in being able to claim this as part of our organisation. It now gives me great pleasure to propose the following resolution : That this meeting welcomes the formation of the Nottingham Section of the Institution of Production Engineers.

MR. GIBBONS (*Nottingham Section President*) : Until quite recently, I must confess, I did not know very much about the Institution of Production Engineers. I knew that Mr. Bingham had taken an active interest in its working, that he had been Chairman of Council, and naturally I thought that if such a new section were mooted in this part of the Midlands, he should be first President, but there seemed to be a general feeling that I should be invited to be your first President. I will do my best, since it is your wish that I should take this position.

It is true, as Lord Sempill and Mr. Bingham have told you, that production engineering has undergone many revolutionary changes in the last few years. That revolution is still in progress. Nottingham surely, with its many present day activities, is quite as important a centre for engineering as Leicester. When you remember that the Government has thought fit to put an important part of Woolwich

Arsenal in this district for present national purposes, I think that is sufficient compliment to Nottingham as a centre of engineering. I understand that at present, at any rate, it is intended that this suggested section should take in Derby and Lincoln, and if that is so, I would say that those areas embrace a wonderful range of engineering productions.

I should like now to touch on some of Mr. Bingham's remarks. He has made technical colleges a little bit of a target. As Sir Ernest Jardine will know, there is an Engineers' Advisory Committee connected with Nottingham University College, and those of us who are on that Committee know that the staff are only too anxious to further the cause of engineering education. I must say in conclusion, that immediately I heard of the suggestion that I should help in starting this section I put out a feeler, and I have been astounded by the demand from many responsible quarters in all kinds of engineering for a section of the Institution here. You have evidence of that in this fine meeting. I have pleasure in seconding Mr. Bingham's resolution.

Mr. J. G. Young (*Chairman of Council*) : It is a pleasure to be here this evening and to support this resolution. Mr. Gibbons, who will make an excellent first president of this new Nottingham section, will find that he will receive whatever support he needs from Members of Council, and other section Committees. There are many Members of Council here to-night, including our past-president, Mr. Scaife. I joined the Institution in 1921, the year it was founded, but Mr. Scaife was already a member. We will do all we can to support Mr. Gibbons and his committee.

Mr. N. V. Kipping (*President, London Section*), said he thought it better to come to the meeting than merely send his greetings and those of the members of the London Section. They were all pleased at the formation of this new Nottingham Section.

Mr. J. H. Barber (*President, Sheffield Section*), conveyed the good wishes of the Sheffield Section. The value of the Institution appealed more and more to all those who know about its activities.

Mr. W. C. Puckey (*Member of Council*), said he felt sure that before long the members of the new Nottingham Section would take the same pride in the Institution as he and others did.

The resolution was then put to the meeting and adopted with enthusiasm.

The election of the following Section Officers was then announced : President, Mr. H. J. Gibbons ; Vice-president, Mr. J. H. Bingham ; Hon. Secretary, Mr. L. Shenton.

Lord Sempill then handed over the chair to Mr. Gibbons, and Mr. Youngash delivered his lecture on "Tool Room Practice," At the conclusion of the discussion on the lecture, votes of thanks to Mr. Youngash, Lord Semphill, and Mr. Gibbons, were adopted.

Planning in a General Engineering Shop

Paper presented to the Institution, Western Section, by J. C. Kerr, Grad. I.P.E.

MOST of you are no doubt familiar with the problems I have in mind—the difficulties of reconciling what ought to go out with what actually goes out ; the difficulties of maintaining a scheduled production and particularly those difficulties which affect a general engineering shop. Actually, of course, the problems are not alone those of an engineering shop but apply to any general production factory.

It is not the purpose of this paper to describe a system and point out how it takes care of everything and where it is theoretically 99.9% efficient. On the contrary, it may rather appear to describe how to make the best of a bad job and give more time to the pointing out of pitfalls than to illustrate the beauties of any particular system. It is hoped, however, to make constructive suggestions. On the basis that the things which ought not to happen frequently decide the way in which things will happen, the paper is practical and the result of experience.

First of all, what has to be considered in a general engineering factory ? I have in mind, primarily, a factory which is producing a variety of products of different sizes which demand the use of different classes of equipment. There is also, however, the case of the factory, frequently a small one, which is producing one essential product in a large range of sizes which necessitate the use of larger plant for certain of the operations or processes, while the question of quantities enters into both conceptions.

We have to consider the planning of the order of production of these varied products, or different sizes of products, and attempt to get a preview of what the position will be at any time over several weeks or months ahead. We probably start off with the knowledge of when the customer wants the job, and that is generally accepted as the date for which to aim.

Let us extend these remarks and first consider the type of article being made. This may be a combination of different classes of product, for example, fans and steam engines, electric motors and coal-cutters, or pumps and tanks, in short, a combination which demands different methods of production for each component. One

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Bristol, October 21, 1938

component may be structural in character, another essentially a machine product, while in another case electric winding may be combined with machining. What I wish to convey is that the finished product may demand dissimilar methods of production for its component parts. It may, in fact, be made in a separate shop. You will all be able to find instances in your own experience. An aero engine and fuselage provide an example, though not relevant to this paper. Your planning may therefore be subject to the vagaries of two sets of factors.

There is a less obvious though similar difficulty to be overcome. Similar products may demand different machines or sizes of machines or processes, for their completion. The product may be one which does not require different classes of labour or method, but it may have considerable variation in design and necessitate the use of different machines or operations to produce certain features. Other major parts of the individual models may be exactly similar to each other or be capable of being worked in the same machines, but the essential feature I have in mind is that some parts of otherwise similar machines require to be finished in a different way or to use a different machine or process. For example, a firm may manufacture steam engines and utilise the same size of framings with different sizes of cylinders. The framings obviously can be completed in the same set of machines, but the cylinders may use two different sizes of boring machines. Again, the gear head housing on a lathe may be different from that of another and necessitate the use of another machine, though the bed and other parts may be capable of being finished on the same machines. What I wish to stress here is that generally similar products may require, to greater or less degree, different plant for their separate production. And now you may perhaps see a connection between this case of similar but differents design products and that of the dissimilar component products previously mentioned.

In similar products it is convenient for our purpose to visualise a simple series line of production, with essential parts moving from machine to machine. We must realise, of course, that there may be a large number of these series lines, but we will consider the one on which our different design part travels and generalise the rest, as though they went through in a parallel flow and gave us no trouble. The fact that they will in practice almost certainly produce trouble merely adds to the complexity of our problem. Our different design part may perhaps travel at first on the same way as its counterpart on other models. For example, it may be marked off, and planed on the same equipment as the other. Later, however, it will branch off on to a different machine or machines and travel on a separate line from the counterpart, to carry out the difference in design. It will be obvious that, if we have a reasonable market for each design,

we cannot hope to keep the machines which follow in the production line after the branch off, as busy as those which are in the production line before the branch off, since the machines in the one case will be working on both designs whereas the machines in the other case will be engaged on one design only. This, of course, is dependent on other things being equal and we know that, in practice, they will almost certainly not be equal. This inequality may help us, but on the whole, is most likely to hinder us and add to the complexity of the problem.

To obtain the maximum of production it is, of course, necessary to keep all machines and equipment working, while efficiency dictates that they must work in co-ordination. It may be argued that it is only necessary to increase the number of machines prior to the branch off, but these may already be sufficient to cover the work available for them.

The planner in a firm manufacturing one dissimilar component product in two designs, has at least three and possibly four parallel or branch lines of production to control. If there are three lines, then co-ordination must be maintained between all three, while with four lines it is necessary to keep two sets of two in step to achieve efficiency.

That is, I think, as reasonably simple as this problem can be presented. Obviously, if more than one dissimilar component product is produced,and if there are a variety of designs, then the parallel or branch lines of production multiply rapidly. It is, of course, not necessary for the dissimilar products to be components of each other. An increase in the parallel lines of production will be produced by dissimilar independent products, but it is not necessary for these to be co-ordinated as is the case with the component products. Added to this there is the question of variation in size of product. Apart from having different designs, each product may be made in a range of sizes, some of which may entail differences in the method of production. This is akin to difference in design, so far as our problem is concerned, and I am going to be content to mention that it increases the lines of production and the difficulties of the planner.

Next I want to mention quantities. A firm may make a variety of products of different production type and each may entail several production lines due to differences in size and design, but it does not follow that it will always have the same quantities going through, with consequent standard times that each machine will be occupied with a particular part of product. A variation in quantity of from one to six of a product is not unreasonable for a general shop.

Again, we must remember that each finished product represents a greater or less number of component parts and that each part may or may not require separate production consideration : and these parts must be co-ordinated in time with each other, to achieve

efficiency. If these parts were in large quantity, the problem would be simply that of the mass production shop where large numbers of standard parts must be closely co-ordinated in time. Also the ones and twos of the general ship may frequently be more vital and cause greater disorganisation if they are scrapped, that the scrapping of a larger number in a mass production shop, since the latter can make more readily for stock and have a buffer supply.

I have several times mentioned the necessity for co-ordination in time. This is desirable not only from a shop efficiency point of view, such as preventing material from lying about the floor, but also to make deliveries in line with promises, which is one of the main desiderata in planning. Shop efficiency may, however, come into conflict with delivery efficiency.

I have tried to analyse the position with which a general shop planner has to deal and I believe I have separated out the major variables that can be foreseen. I want you to think of these variables in terms of machine loading.

The load on any machine is going to depend on the orders received, not only in terms of their quantity, but also in terms of their type, design and size. To take an extreme case, the load on a machine used only for one product will be nil if all the orders are for other products. What is the position of a general purpose machine, which may be making parts for all products on order but whose output must be co-ordinated with other machines which can be used only on one or two of the products on order? It is obvious that the machine working on all products on order will develop into a bottle neck and that the speed of output of that machine will become the speed of output of all the products on order. Bear in mind that if different products were on order then this machine might not be so fully loaded, though other machines might be busier or, in turn, become the bottle neck. This question will be dealt with later in a different way. Various adaptations of mass production systems have been tried in general shops, but the problem is still with us. The failure of such systems lies, I think, in that, consciously or unconsciously, they are based on quantity, and do not take suitable account of the variations. They perhaps start with the idea that each part must be known and specified by drawing or code number. Each item may be provided with a cost card, material card, label, manufacturing order, job card, etc., while the general operation of the system may call for Gantt charts, master process cards, daily work-done sheets, reasons for delay sheets, replace order cards and other forms which take care of each apparent possible reed. I am not attempting to minimize the usefulness of each and all of these aids to good organization, but, on the contrary, appreciate their use, if not essential

use, in their sphere. I have enumerated them for the purpose of considering how we might apply them to a general shop.

Hypothetical System

Let us assume that we can make up a standard lay-out sheet or master process card, which, while it may not always be able to give time allowed per piece, may at least be able to show a standard method of production to which only time must be attached when an order is received. When the notification of order arrives, it is then only necessary for the planner to arrange that the drawings are quickly available for the order of raw material and the fixing of production times. I am not going to discuss whether a plan should be made on the basis of anticipated raw material delivery, or only on the actual receipt of the material, but am content to say that anticipated but unfulfilled raw material deliveries will put a spanner through the machinery of any plan. We will assume that no plan is made until the material is received.

The material card and label can be made out immediately following or even along with the order for the material, and while we are awaiting receipt of this we can make out the remaining cards as soon as the production times have been fixed. The manufacturing or job orders will be made out as copies of the master card, but with the addition of quantities, extended times, drawing numbers, job number, routing, etc. The actual job cards or piece-work lines, or whatever they may be called, can be made out along with the cost cards and all of these placed in appropriate suspension files until the material is available. The label and material card may perhaps be kept in the stores office, and when the material arrives the label affixed to it and the material card sent to the planning department as advice of material arrived. Or the cards may all be held in the central planning department and another form of advice, such as the suppliers advice note, used to notify delivery. Each method has advantages, some of which depend on circumstances.

When the material has been received, or perhaps a sufficiency of the major parts, planning can commence. The manufacturing orders, job cards, material cards and cost cards may then be taken from the suspension files and go to the charting section of the planning department. The detail operations, with class of machine for each operation and times, shown on the manufacturing order, would be used by the planner in deciding which machine would do the operation. This would be arrived at in conformity with the loads already charted against the individual machines of the particular class. It should perhaps have been mentioned that for each operation shown on the manufacturing order there is an

individual job card. Each operation on the order would be indicated on the chart in terms of the number of hours estimated for it and the job number would be shown against the machine allocated. As you are aware, a Gantt chart is divided by horizontal and vertical lines, and each vertical space can be made to represent a space of time, say one hour, while the horizontal spaces can represent individual machines. Each operation, then, can be represented in time by the length of a line drawn opposite the number of the machine doing the work. The total length of the line drawn against any machine represents the work-load on the machine. Appropriate symbols can be used to indicate starting, stopping and finishing of work.

When a machine has been allocated for a particular operation, both the manufacturing order and the appropriate job card would be marked with the number of the machine and the order of production. The cost card would also be marked with the machine number. At arranged times, say once a week, the job or operation cards would be distributed to the production clerks in the various departments throughout the shop. The material card would be sent to the department first mentioned on the manufacturing order, while the latter could be sent to the store and the cost card to the cost office. The issue of all these cards can be controlled by the central planning department in such a way that no machine would have more than a certain amount of work on hand, and this would be due to finish when the next issue of cards was made. This would give closer control over the work actually being carried out and prevent the flooding of the shop with cards for work not wanted in the immediate future. In this, the risk of loss of cards would also be mitigated.

When the production clerk in a section received his issue of job cards he would file them in the order of production required against each particular machine. Where job cards were accompanied by a material card, that is first operation jobs, the section planner would send the latter card to the store some time before the job was due to start. The stores would take out the manufacturing order and deliver the material to the first-mentioned machine and hand the manufacturing order to the production clerk or planner in the section. This would act as advice of receipt of material.

The machine operator would come to the section progress office for his next job and the production clerk would show him the job card with the time allowed or give him a duplicate card. The operator would identify the material at his machine by the label attached. The production clerk would mark in the actual time when the job was commenced. On completion of the job, the operator would receive his next job from the production clerk, who would stamp the finishing time on the old job and the starting

time on the new one. After the finished operation has been inspected the manufacturing order and the job operation card can be appropriately marked, while the number of the operation will be marked on the daily work-done sheet. The manufacturing order would then be handed to the transport department or to the move man attached to the section. This would act as advice of material to be moved from the machine shown on the card to the next operation, also shown on the card. On the material being transferred, the card would be handed to the production clerk in the section concerned. This acts as advice of job available at the machine or place shown on the card and the production clerk would consult his operation cards if the job was due immediately as shown by the manufacturing order.

Finished operation cards would go to the cost department for entry in their record and then be passed to the wages department. All jobs completed in any one day would be accounted for, either in the daily work-done sheet or in a reasons-for-delay sheet. These sheets would be sent by each section in the shop to the central planning department where the work completed would be marked off on their charts, and the work not carried out investigated and replanned. It will be observed that no mention has been made of tools and other items. This is to avoid unnecessary complication.

Shop Capacity.

The capacity of a shop may perhaps be defined as the quantity of a product which it can produce in a given time, under normal operating conditions.

In a shop producing large quantities of an article, it is very easy to arrive at an actual figure of capacity, and it is also easy to know this, for a shop making several different products, each on a separate production line and each having its separate equipment. In such cases, the exact amount of work that each production section has to do can reasonably be determined over a period of time. Machining or other processes become repetitive and impediments in the production flow become obvious and, in the majority of cases, easy to handle. Machines become identified with one product only, or even with only one operation on a component of the product.

The capacity of such a factory in terms of any one product is then simply dependent on the time which the slowest component takes to pass along the production line. In a completely balanced factory, of course, all components would come together, as and when required for assembly. In laying out the plant, this might mean in some cases the duplication of the production line of certain components in order to speed up their production and synchronise with other components. Or it might mean using a machine or

machines for operations on different components, in order to keep it working full time. Once, however, that the production method, with times and plant layout, was fixed, the operations from then on would be repetitive, and the minimum of trouble experienced. Faulty material, or unforseeable contingencies of any kind are, of course, not being considered at the moment. In such conditions, orders would probably go through the shops for stock. A certain amount of stock would, no doubt, be carried in the warehouse and act as a buffer against contingencies, such as machine breakdown, scrap, etc.

In a general shop, however, the production line is not laid down in such preconceived fashion. Economically, it cannot be laid down in such a way, since every different product has a different production line, depending, as has already been shown, on design and size, and quantities are few.

The plant, then, may be laid out to suit the size of the machines or their proximity to power. Again it may be laid out in groups of similar machines or, as is probably frequent, a machine may be placed as circumstances dictate at the time of its buying. Obviously, such layouts increase transport and handling costs, while they also mean loss of time, by comparison with plant laid out in the sequence of operations.

These machines individually are going to be used to a greater or less degree in accordance with the orders received for the different type products. If, by chance, it happed that all orders were for one size and design of product, then obviously the machines used for that product should be working to capacity, assuming a sufficiency of orders. A machine which only had a small amount of work relative to this product would, however, be working under capacity, while machines not required at all for the product would represent idle capacity though, of course, they would be required if products of another type were on order. Again, machines which were usuable on all types of product, could become overloaded if various combinations of orders for different products were received. The time of use of any machine, then, is going to be determined by the nature of the products ordered, and this is a variable. The output of the shop depends on the use made of the plant, and since this is a variable depending on the nature of the orders received, it follows that the shop output depends on the nature, or kind of combination made by the orders received. That is, the shop capacity is variable. The load on the machines is variable and co-ordination in time, between the parts being produced on different machines is, consequently, exceedingly difficult. And to plan successfully, we must have the maximum of co-ordination in the production of the various parts. In achieving maximum co-ordination it may not be possible

to make full use of the maximum machine hours available in the shop.

Let us try to illustrate that. Assume that a factory's production was perfectly balanced in the manufacture of five structural steel tanks, 10 pumps, and 10 engines per week. By " balanced " is meant that every machine and piece of equipment was capable of being worked in step with every other machine, that parts would come off machines and go on to others as required, and that all the plant worked for the same time during the week, with nothing idle or overworked. Suppose that the structural parts made use of drilling machines which were also used for the other products. In a particular week or period of time, orders for four tanks, 10 pumps, and 11 engines, might be required according to customers' demands. The actual drilling time of the one extra engine we will assume to be the same as the drilling time for the tank, and the machine hours of the drilling machines are thus sufficient for the change in orders. However, since our plant was completely balanced before, with no machines idle, we will not be able to produce the cylinder or framing for the extra engine from the other machines which are involved in their manufacture prior to drilling, and thus we would be unable to use all the available capacity of the drilling machines, despite the fact that there is work for them if it could come forward. It would, perhaps, be better to say that the extra cylinder, etc., would not be ready for drilling when the drilling machine was idle, and I am sure that you will all have met that in your experience. Again, the demand might be for five tanks, eight pumps, and 12 engines. The pumps and engines might use the same machines for their production, but the boring, say, of the engine cylinders might take longer than the same operation on the pumps. The increased quantity of engines would thus make the boring machine late, in carrying out work which it may have to do on other parts. These parts would consequently be late for future operations, and machines or assemblies may have to be kept idle until the parts are available. For example, if we assume that the boring mill is working forty-seven hours and that its output, under balanced conditions, is made up of 10 engine cylinders representing twenty-five hours, 10 pump cylinders totalling fifteen hours, and brackets or miscellaneous work covering the remaining seven hours, that is two and a half hours per engine cylinder and one and a half hours per pump cylinder, than in the event of orders for 12 engines and eight pumps, the hours of work on them have become $12 \times 2\frac{1}{2}$ and $8 \times 1\frac{1}{2}$, or a toal of forty-two hours. If we assume that the brackets still require the same time, i.e., seven hours, we have now a total of forty-nine hours of work for the machine or two hours more than its working time. This means that the brackets, if they are last in production order, as is feasible, would be two hours late for their next operation,

say, drilling, which means, in an otherwise balanced shop, that the machine would be idle for two hours waiting on the parts coming off the boring machine.

Again, there is the obvious case of the orders being all for one type of product, say, 20 tanks, which might be quite good financially, but would leave idle the machines used on pumps and engines, though the structural plant would be unable to cope with the order for tanks within the time.

That is a very simple explanation of available but unusable capacity. We only considered the effect on production of a variation in customers' demand ; a variation of the combination of orders received, which is an external variation beyond the firm's control. We took no account of possible variations in size or design of product, with consequent differences in time and method of production, etc. When you couple these variations with the actual fluctuations in demand and the possibility of a greater number of different products, it will be obvious that tremendous number of combinations of production order are possible. Various of these may, of course, be quite suitable, but others will not result in the maximum production in a given time. The brackets, in the case illustrated, might possibly have required five hours on the boring machine instead of seven, owing to the difference in the combination of orders. In other words, the change in orders which caused the increase in the total time for boring the engine cylinders, might have caused an equal reduction of time in the machining of the brackets, and given the boring machine at least its normal forty-seven hours of work. However, equally possible, the brackets might have required more time with consequent greater disorganisation. The point is that these variations exist and their cumulative effect will prevent any rational system from functioning to its best advantage in a general shop. There are obvious remedies, such as overtime, etc., for many difficulties, but they do not provide a complete solution. Whatever remedies are utilised, much depends on the personal ingenuity of the planner, and that is independent of system.

Charting the machine load.

Lest us consider what would happen if we utilised our hypothetical system in such circumstances. An order having been received and the drawings available, it is only necessary to order the material and begin the preparation of cards. The issue of cards and work to the shop becomes a mechanical operation under the system and mistakes will be due to the human factor. Transfer of material from section to section comes within the same category. A man's next job will be known, material will not readily be lost and the exact position of each individal component will be quickly known, and from this a reasonable estimate of the indivual position of any

order should be obtainable. It should thus be easy to tell when it is likely to be finished or to give it preferential treatment. It is important, by the way, to remember that if one job is brought ahead of five others each of these five is stepped back by the amount of time it takes to do the one off.

The way in which the loads are allocated against the various machines will largely decide the position of the individual jobs at any later date. The successful functioning of the system, therefore, depends on good charting, and it is here that skill and ingenuity can be exercised. Here too, defects can be shown up. When several orders have to be charted it seems obvious that the one which has to be delivered first, should be machined first, and consequently shown first on the chart.

Suppose we have orders for three products, which we will call A, B, and C. and that there is three hours turning, two hours milling, and one hour of drilling for components of product A and that products B and C have similar amounts of work on them. For the sake of simplicity, let us consider that these operations are to be carried out on separate components of A, *i.e.*, one component has to be turned, another milled and another drilled, so that each machine is occupied by one component for the time already specified. Let A be required first, B second, and C last. We will then show A first on our chart, with B and C following.

The chart will show at a glance the amount of work against each machine. It will be obvious that the lathe has more work than the other machines and that delivery of the products therefore depends on the output of the lathe. Overtime might appear to be worth while. From the chart it appears that the machine were all availabe at the same time, but, quite possibly, one or other machine might have been engaged on work which would have pushed back each job on that machine. As the chart stands, however, each job would be finished in its turn and, if the maximum permissible hours were being worked on each machine, then they could not be produced any faster and the drilled part of job C would require to wait intil the turned part came off the lathe for assembly. It might be sent to the store, though again it might be left to take up room on the floor. Whatever happens to it the part is not actually required at the moment.

Let us take another case. Suppose that we have orders for three other products D, E, and F, and that D has a component with seven turning and one with three hours milling, while a third has fours drilling. Product E has components which have, respectively, five hours turning, three hours milling, and four hours drilling, while product F has no turning, one hours milling followed by an hour's drilling on one component, and three hours fabrication followed by

three hours welding on another. Let us assume that D is required first, E second and F last. Our chart might then be as follows :—

Hours

Turn M/c		JO	B	D					JO	B	E	
Mill M/c	JO	B	D	JO	B	E	JOB F					
Drill M/c	JO	B	D		JO	B	E		JOB F			
Fabricate	JO	B	F									
Weld				JO	B	F						

Examination of the chart shows that the lathe again is going to determine the delivery of two of the jobs. Notice, however, that job F is going to be produced before job E despite the fact that it was not wanted until the last. And observe that this has been achieved by strictly following the principle that the job required first shall be machined first. Apparently this principle does not always produce the job first.

Again, supposing that each of the jobs had been wanted earlier, but that pressure of work is going to make them late in being delivered : by that is meant that jobs required before them are occupying the machines and jobs D, E, and F will simply have to take their turn. Observe, then, that it would have been quite possible to mill and drill job F before job E without in the least holding back the delivery of job E, while job F could this have been delivered earlier, with possible greater satisfaction to the customer This is possible becuase job E cannot be delivered until after its component is finished in the lathe, which is some time after the completion of the components being milled and drilled.

You will also perhaps be able to visualise a case, where the orders on hand all involved a large amount of, say, turning, to the extent

of hopelessly overloading the available machines and preventing components which had following operations, say, drilling, from getting through the lathes to their next operation, the machines for which might be comparatively lightly loaded or even standing idle, though perhaps, they would be busy enough with components from off the mills, by the time the components from the lathes did get through. A judicious re-adjustment of the lathe or mill loads might have allowed of work being brougnt forward without expense of delivery time on any other job.

These examples should, I think, be sufficient to illustrate that this business of charting cannot simply be approached on the basis of putting down the first wanted job, first on the chart. If such a method were followed, it might only succeed in producting a large number of components, which could not be assembled for lack of other components which were tied up in the machine loads. This means extra storage space or material getting in the way, money lying out and such annoyance, besides dissatisfied customers. It means also that assembled output will tend to alternate between peaks and depressions, since a large number of orders may only be awaiting one part on each and will all move inmediately that part is received.

Possible Cures.

Let us consider by what means we may ameliorate this state of affairs which we find despite our system. There is hardly any doubt that we should continue to plan ahead, since while we may be much short of perfection, conditions as regards delivery would almost certainly be worse if left to the discretion of the shop foreman or officials. If nothing more, the system will always tell the management what is not being done and provide means of estimating the position of jobs, within a reasonable time.

Deliveries should only be quoted by the planning department and it should be up to salesmen to get their clients to accept this time or to find out the real time by which the client will need the job. The moral effect of completing a job to client's time and then discovering that conditions prevent his taking delivery can be very bad, apart fron any disorganisation caused or space taken up. It is important to know that the dates for which your are planning are reasonably correct. We have to remember that we are trying to adapt a more or less rigid system to a set of conditions which are highly variable. Admittedly, we may have taken into accoint many variables, but it is not feasible that we can cover all the variables that can occur in a general engineering shop. It seems to me, therefore, that some method of compromise is indicated whereby the sytem may be made more flexible and the shop conditions reduced in their variability. This means more than the planning

or adjustment of a system. It also means the planning of the shop and products so that they will aid and not hinder the flow of production.

From our consideration of the planning charts, we saw one obvious way in which we could raise our production over a given period. That was to change the order of production of suitable component parts instead of slavishily keeping them in the order in which they had been asked for. From a practical point of view, however this has only a limited application, since it calls for a continuous application to detail which migh involve an increased staff or undue strain on an existing one, where the load on the machine was highly variable. If we could reduce the variability of this load and know that certain machines could safely be left to routine planning, then we could more easily adjust the load on the remaining machines which still had to deal with a variable load.

One method of fixing the load on a machine is to make stock. Normally, this might be a very limited amount, but if we standardise everything we can on a product, and between products, then we may be able to make common components as finished part stocks. Bolts and nuts illustrate this idea, since they are common components which are kept in fair quantity for standard sizes. Supporting legs for switchgear or lathes, base mountings for fans, brackets for many purposes, frames and other items should, wherever possible, be made suitable for different sizes of the same product and for different kinds of products. This, of course, would require very good drawing office and stock control systems. Reciprocating pumps, engines, and air compressors offer an apparently good example for common components. Where the parts must be different, build them to suit the standard components. The advantages of this are considerable. It would allow of certain machines being occupied on standard work for stock and thus give them a load which will not be affected by work on other machines. They will be apart from the variable load and its affects, so long as they are on stock. Work will be issued to them in greater quantities and so reduce the paper and clerical work which would be required if each part were issued as a separate job. The paper of the system can be a much bigger problem in a general shop than in a mass production shop, since quantities are fewer, while varieties are greater in the former and each job will require separate cards. Another big advantage is that deliveries may be speeded up owing to certain parts being in stock, with consequent fewer parts to be made.

It is, of course, not possible to stock certain parts, but it may be possible to lay out a line of machines which will give straight line production to parts of different products. Take again the example of small steam engines and pumps. It may not be possible to stock the cylinders of these, owing to differences in the bore, but general

purpose machines have some latitude in the sizes which they can take and various sizes of engine and pump cylinders should be able to go on the same production line. Various sizes of lathe beds, tail stocks, etc. might be able to move from machine to machine on the same production line, though the parts may be for different sizes or types of products. In many shops there is a considerable number of parts which are screwed and then milled. Why should not one machine or two do all the screwing and pass the work on to a milling machine immediately beside it, instead of the screwing being distributed around the various machines capable of doing it? The advantages of such a method is that the kind of work which these machines will be doing is already known to some degree and planning for them becomes mere routine, transport will be reduced, as also will be the number of machines working on whatever comes along, that is, the machines on the variable load will be reduced and so allow of easier manipulation of the loads against them. Admittedly, such a method of sectionalising is not always possible and, if not carefully handled, may result in loading up machines with too much work, but some of this may be jettisoned on to the machines on variable load and we are no worse off than if the method was not practised, while some advantage is still gained for the parts machined by the section.

Another method is to separate out different products into self-contained sections and lay out the necessary machines in the order of operations. This, is more suited for parts or products which are on their own and are not required in line with other products, that is, products which are not component products.

The whole idea of this sectionalising is to give the machines certain standard work to do in sequence with other machines. This should smooth the flow of production, as it does in a one product shop, and by reducing the number of machines which do various operations on different parts of different products, make it more easy to manipulate the load on them. Should slackness occur on those machines which are sectionalised, then they may be able to take some of the machines on the variable load for a time, which will be capable of estimation from the chart: that is, the sectionalised machines may return for a time to machining any parts which come along.

So far as the length of time which one should plan ahead is concerned, that depends very largely on the type of product, but whatever time there may be on hand, it is always better to plan roughly as far ahead as possible and breakdown to actual conditions as they arise. This may involve planning a job several times, but if it results in the job going through efficiently then it will have been worth while. In thinking of planning, it has several times occurred to me that it is not so much a cut and dried method which is wanted as a series

of guides or correctives which would come automatically into action when a job threatened to go off the path on which it had been started.

Lastly there is the question of spares and replacements. These are a fruitful source of trouble since they break into machines, spoil the production flow, and hold up jobs. It seems to me that it would be best to do these on a separate section of representative machines, say one of each, and to do maintenance work and all other odd jobs in that section. While this might not be a complete solution, it would minimise the trouble

Discussion

Mr. Daniels: The author has given us a paper on a subject in which we are all interested, and I feel that it is a matter which has given us all a lot of trouble. I have my own opinions on the subject, but I have others with me to-night who have had a lot of experience in these matters and are more competent to speak than I. In the matter of charts, job cards, and other records, I am sure we shall be glad to hear the views of those who have had the experience of the working of these for some years. One thing we have done in our business (and I expect others have had to do it) is to re-group the machines to suit the progress of the work in hand. If the machines are re-grouped one can save a lot of time on transport from one machine to the other. In the Great War we found it was worth our while to re-arrange the machines in sequence. We would cease work and re-group the machines during the week-end, and thereby effect an enormous saving in time. Another sore point is the time of delivery. If anyone can solve that difficulty we shall bless him. You promise a customer that he can have his job in three weeks and you do your best to keep within the time promised. Then another customer comes along with a very urgent job—perhaps you know the people very well, and you can't put them off. What can you do? The first job gets delayed. At the end of three weeks we say it will be three more weeks, and so on. You are always up against it, and obviously you have to disorganise your programme to fit in the work. A job is going to take three months, and the customer wants it in three weeks. We know if we say we cannot do it in the time he will get someone else to promise to do it, and we should lose the order, so we say we *can* do it, and at the end of six weeks the customer may get the job. We must remember that jobs are sometimes lost because a customer finds that he cannot get delivery on the dates promised. Then another case, where you work night and day in the shop and then find your customer does not need it so soon. I had a job like that recently, and it takes the heart out of the men. You urge the men on to get it done and then you find the customer cannot take delivery. You want, above all things, to get it out of your shop. After working night and day to get the thing completed you still have it on your hands.

Mr. Warner: The author suggested that when we fail to keep the machines employed and when some machines are lying idle waiting for parts to come off other machines, they should be put to work on standard parts intended for stock. To my mind you cannot do it, because making for stock is a very difficult thing.

You would have to have an efficient system for obtaining material out of store, putting it on the production line, and taking off and putting back into store again, as fluctuations in normal production demanded. Although accustomed to think the definition of a general engineering shop has a very wide significance, by the tone of the author's remarks I do not think he has in mind the average general engineering shop. I agree with Mr. Daniels, judging by what he says, that the personal element in a general engineering shop is so great that all the planning schemes fall down. In the case of a successful mass production type of planning system, I think the planner must be supreme; but in the case of a general engineering shop, what is generally needed is a master mind, not tied to any particular plan, a personality familiar with the capacity and resources of the shop. The master mind must be ready to throw one job aside for another. You cannot tell how long that break-down job or special job is going to take, but you can alter the sequence of operations on any machines until operations that have been delayed can be resumed. I do not think the author really refers to a general engineering shop in his reference to various operations. I know that, most of the time, in a general engineering shop you are forced to make shift. In the first place you have a set of machines, not bought with any special purpose in view. You have to wangle and scheme, as a planner does not, with what may be in the shop.

Mr. Kerr: I agree and disagree with Mr. Warner. I disagree with filling in the odd time by making stock. What I did intend to convey was that you could sectionalise certain parts to certain certain machines, and possibly do stock work. It is really a case of giving them routine work and where you can do nothing else you must put them on general work, but I did not intend to convey that when you cannot get work forward you should simply fill your stores with stock as, of course, it might be of a kind rarely wanted and you would accumulate too much. I did have in mind a general engineering shop, perhaps the last speaker might have a different conception of the term. I have seen a system, such as the hypothetical one described, in a shop which produced, I think, about six or more types of products, all of a different nature, in an immense variety of sizes and designs and utterly different in their methods of production. Conditions of site affect the design of outside work. Consequently there was no full opportunity of knowing what the job would be like until you got the contract. You did not know too well then. Such a system has been applied and things have improved.

Mr. Dauncey: I do not agree with Mr. Warner that you cannot plan in a general engineering shop. We are doing it, and very successfully in some instances. We find that we cannot at present plan

everything, but some of our things are planned very successfully, and it is a great help. The greatest difficulty we find is with the salesmen and the powers that be, in promising things that are impossible. I think the author said the planning department should be consulted before giving a delivery date.

MR. DANIELS: We do it by sectionalising. Mr. Dauncey has one shop dealing with one thing and another with a different product. It takes a long time to break the men in and we keep them to that one shop, and we leave them to deal with the work. We have many kinds of entirely different work, components in one part of the works, and another section on work of a different kind, another on machining work, etc. It is a matter of a small shop inside a bigger one. We find it helpful. When we get an order proper planning is important. I get a telephone call—they say "Hurry it up a bit"—although it may be a tremendously difficult job, the shop is keeping down to it, but I have to upset them. A customer from a very important works comes along with a breakdown, the factory is stopped, "they have five hundred people employed"—we must get a move on; is it worth while upsetting the production to get that work? You may say, "We are paid for it," but if you stop production you cannot do a cheap job. It may not pay us, but we maintain our connection.

MR. KERR: Mr. Dauncey raised the point about the sales department consulting the planning department. I admit that business might be lost through quoting a date that is too long; it will also be lost if you quote a delivery date you cannot meet. Both cases arise, and if you quote dates that you can reasonably make, then if you have to make a revision at any time, you are more likely to get it agreeably. Many firms who ask for a job may not want it for six months, but they say two months, because they know you will take six. If you can promise to do things, and do what you have promised, people will rely on you and you can more readily rely on their dates being accurate. Perhaps I should make some remarks on what Mr. Daniels said earlier on this question of planning. Mr. Daniels mentioned that he found it worth while during the last war actually to shift round the machines to meet the sequence of operations. I agree that that angle should be considered. This is not simply delivery planning, if you get down to it. It means planning your shop lay-out and how you are going to do a thing, and the time you will take doing it. But, otherwise, you have no conception of what can be done; only just hoping you can do it. Aim to have some conception of what the shop can do. To have some idea is only common sense. Human nature being what it is, people take chances in quoting a delivery date; they hate to think they may lose the job.

MR. MOORMAN: Mr. Kerr mentioned in his lecture the number

of cards made out—at least four for every job. If this is so, the planning department is a large department and must necessitate a large number of clerks to deal with the work. I would like to know what proportion of his wage bill he would consider reasonable to spend on his planning system ? Also, in his system, what is the foreman's job—just a policeman and nothing else ? One of our methods is to have a monthly conference, presided over by one of the directors of the works, the works manager, the production engineer, and all the foremen, on the first Monday in each month. The jobs that have to be given precedence are considered and each foreman has a say, and if a foreman carries out his instructions and his material comes through to the machine shop, although he could not say where any job is going, he keeps the machines fully occupied and we get our delivery.

Mr. Kerr : In such a system as I outlined, the staff would increase, certainly. I was not advocating a system of planning so much as analysing the trouble to be met with in using such a system. While you may leave it to foremen or to under-foremen to place work in machines and put it in hand exactly as you want it, you must have had your staff a long time, and they must know the product thoroughly. It seems to me you want, as far as possible, to be able to turn the allocation of jobs into routine work, so that you can stand the maximum variation in staff. In such a system a foreman's job is to make things to pass inspection, to know the capabilities of his men and his machines and to keep discipline. Some very high class mass production firms have separate executives for machines, etc. I am not discussing that. If you increase your planning staff you can quite possibly reduce your staff of foremen. From that point of view you can, perhaps, turn your foremen into planners. You are already using your foremen as planners, whether you realize it or not, in leaving them to allocate work. They plan the work and it is on their memories and note books that they rely. Why not give them better tools ? In one case I know of, to operate such a system as Mr. Moorman may operate, you might have a foreman to each machine section. Now I know cases where with care and skill under-foremen were not necessary, and their places were taken by much lower paid routine clerks. At the same time a skilled man knows best what the machines can do, and is essential for the key positions. With routine work he would be better employed in the office deciding what machines would do the work. Give him something whereby he can see the load on all the machines. He can see where he stands, how much he has got against any machine. It would not be 100% efficient every time, but under any circumstances it is, I think, desirable.

Mr. H. C. Dyer : From my experience it is not usual to have machines working on stock parts only. In a general engineering

shop one does not often require a sufficiently large number of machined parts for stock to warrant keeping a special section of machines for the production of those parts. Actually, what usually happens when a stock order is put into the shop is that machines usually engaged on general work are put into production of the stock parts. Another point concerning progress charts. In a case where you make, say, about 300 different types of products, do you mean to say you have one line, or series of lines, for each component part of a product? If so, one would have to have an office whose size would not be warranted. Again, some form of index system would be required for helping to find the progress of any part, and for the upkeep of these indexed systems and the charts, skilled people would be required to look after them, and keep them up to date. In a general engineering shop where you have, say, an order for one small machined part, the compilation of the chart and index and the looking up of any details that the record of progress would require, would swallow up all the profits from the job in the payment of wages, overheads, etc. The author says that the chart system is working satisfactorily in a factory making only six types of a certain kind of product. The firm in which I am employed makes 300 different types. With regard to the sectionalising business, I think that when the author starts sectionalising the machine shop, he immediately brings in the mass production principle. If you get an order for, say, 200 of one article, you can pick certain machines off for that job, and since they will most likely go through the shops on a bonus basis, mass production is brought into being and progress charts can easily be adapted for this type of production. The point is, can we do the same thing with one small job, such as a piston? In these cases where we have odds and ends coming in, the planner uses his discretion and experience to help him get the work through the shops as quickly as possible, and, in all probability, the chart with its companion index system would be more of a hindrance than a help.

Mr. Kerr: You find it difficult to make machines run for stock. I suggested making stock where possible and increasing the chances of making stock by attention to design, etc. This was one of the points only, and where not practicable some other means of reducing the variable load should be tried, perhaps as those suggested in the paper. The paper purports to analyse and suggest, not to lay down hard and fast rules. You mentioned an index system—trying to find something in the shop. I will put it to you another way. How long will it take you to find a part or a complete job without an index of some kind? Nobody knows where the parts are. No one can tell you. I did not say the system was satisfactory in the case I quoted. I said things were better that they were before and I did not wish to

convey satisfaction. What do you mean by types? When I said six types I meant radically different products, but one of them—I am thinking of centrifugal fans—may be made in 10 different types of fan and each of the 10 may be made in 20 different sizes and, say, three different thicknesses or classes of material. Now it depends on what you mean by types. The essential thing I want to get at is anything that causes a difference in the production method. If you have 60 radically different products on this basis, course, it is very difficult to help yourself. So far as the odd piston is concerned, it seems to me that odds and ends like that are better dealt with in a separate section which handles all oddments, such as spares, etc.

MR. BURGOINE (Section President, who presided): We have had a really good discussion and I am not going to spend much time in summing up on one or two points. The author has used an illustration of a pump driven by a steam engine, and he more or less suggests that it is possible to make a lot of parts common to different types and sizes. It so happens that I was once called upon to design a range of three sizes of steam-driven pumps, with as many common parts as possible. One of the three sizes looked a proper design, but the others were utterly rotten. In connection with planning, a shop I was in as a young man had no planning system whatsoever. The firm did the best they could, and we held the world's record for broken delivery promises! I know lots of shops with really good organisation, thousands of cards and mechanical accounting machines, all of the very latest design, and I know that hardly one firm ever keeps a delivery promise. As regards getting information quickly from charts, there was one big firm in America which I knew very well, that had a really fine system. If a customer rang up to ask when would he get his order, the manager would send for his assistant in the planning department who would go and turn up his charts. He would then use the house telephone, and get the foreman and say, " Bill, when are we going to get so-and-so's work done? and he would say " Tuesday week," and the customer would probably get it Tuesday fortnight. That was how their planning system worked! I think the difficulty of planning in a general engineering shop does not lend itself to systematic planning.